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ABSTRACT

Competence in action perception seems to be achieved very early in life. Because research has indicated that competent perceivers of action must be able to discriminate breakpoints in behavior, then recognition memory for breakpoints should be superior to that for nonbreakpoints at all ages where competence in action perception exists. Two studies of the development of action perception were conducted concurrently with adults (N=16) and children ages five (N=17), eight (N=16), and ten (N=16). Subjects were tested for recognition memory using slides of breakpoints and nonbreakpoints, and were asked to judge the ordering of triads of breakpoints and nonbreakpoints presented in correct and incorrect order. Recognition accuracy for breakpoints was superior to that for nonbreakpoints at all age levels, suggesting that at least by the age of five, children's perception of behavior is not fundamentally different from that of adults. The examination of children's ability to use breakpoint information, independent of their ability to select breakpoints from ongoing behavior, revealed that although overall breakpoint triads were judged more accurately than nonbreakpoint triads, kindergarteners differed from older subjects in the manner in which they made their judgments. (Author/NRB)

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The Development of Action Discrimination

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Abstract

Two studies of the development of action perception were conducted concurrently with 65 adults and children five, eight and ten years old. One study tested recognition memory for breakpoints and nonbreakpoints. Recognition accuracy for breakpoints was superior to that for nonbreakpoints at all age levels. In a second study, subjects viewed triads of slides consisting of three consecutive breakpoints or nonbreakpoints. Order of presentation was also varied. Results indicated that, overall, subjects were more accurate in their judgments of correctness of breakpoint slide ordering, but that five-year-olds differed from older subjects in the manner in which they made their judgments.

The organization of the behavior stream into perceived action units seems to result from an interaction of cognitive structures and available stimulus information (Newtson, 1980). Insofar as constraints upon this interaction result from the nature of the behavior stream as a stimulus, they should apply to all perceivers capable of comprehending behavioral information. Insofar as constraints depend on cognitive structures of the perceiver, however, they can be expected to vary more systematically across perceivers and hence to mediate differences in the interpretation of action. In the present article, we report two studies of the development of action perception directed at clarifying this interaction.

Competence in action perception seems to be achieved very early in life. Livesley and Bromley (1973) investigated children's (ages 4-8) ability to narrate films as they watched them, and compared their narratives to those of adults. They concluded that, "Behavior narratives are competent from about the age of 6 years ... (Livesley & Bromley, 1973, p. 256)." They were well aware, however, that they were relying on verbal reports of a nonverbal process, and that competence in perceptual organization might be achieved much earlier.

Smith (1978) found that four-year-olds could give accurate descriptions of "what happened" when viewing brief videotapes of relatively simple action sequences. In Smith's (1978) study, children aged 4, 5 and 6 years were shown sequences depiciting voluntary, involuntary (e.g. sneezing) and "object-like" (e.g. being pushed aside) movement. Accuracy of description of the action did not show age trends at all, and was equivalent to that of an adult sample. Smith (1978) did observe significant changes over age in the ability to interpret action, however. Four-year-olds discriminated "object-like" movements as less intentional than involuntary or voluntary actions; five-year-olds discriminated all three classes of action from each other in their degree of intentionality although not strongly six-year-olds and adults did. Between ages five and six, children became able to eliminate "object-like" movements as reflecting inten-

tionality as well as adults, and saw involuntary actions as significantly less intentional (although still not as unintentional as perceived by adults).

Brown (1976) has performed extensive studies of children's ability to construct and reconstruct events. Her research has employed a variety of picture arrangement paradigms, as well as situations in which children reconstructed events that they had seen performed. Brown (1976) reviews an impressive array of evidence that children's ability to reason about events becomes much more sophisticated between five and six years of age. Even very young children, however, were found to be capable of accurate descriptions of events presented in a logical, meaningful order.

Stimulus constraints in action perception. Studies of action perception with adults imply that the critical information for action perception is available only intermittently in the behavior stream. For instance, Newtson, Engquist and Bois (1977) analyzed the movement structure (i.e. the degree of change in position from second to second) in seven diverse behavior sequences totalling about 18 minutes in duration. They found that, in these sequences, the behavior stream consisted of periods of a low degree of relatively smooth movement, punctuated by points of high magnitude movement. When adult observers were asked to divide a stream of behavior into its component actions by pressing a button whenever, in their judgment, an action occurred, actions were marked as occurring at these points of high magnitude change. These points at which action units were discriminated have been termed "breakpoints," intervening stimulus intervals have been called "nonbreakpoints." On the average, ten to fifteen per cent of the one-second intervals were identified as breakpoints (Newtson, Engquist & Bois, 1976; 1977).

Converging evidence from a number of studies has supported this picture of action perception. Newtson and Engquist (1976) cut out film from nine short sequences at breakpoints and at nonbreakpoints, and asked adults to detect these

omissions. Consistent with the view that high magnitude changes occur at breakpoints, deletions at breakpoints were detected with greater accuracy than those at nonbreakpoints. Newtson and Engquist (1976) reported two additional studies confirming the informational value of breakpoints. In one study, breakpoints and nonbreakpoints (as identified by the judgments of a pretest group) were photographed and mounted as slides. Adult subjects viewed the films and then took a recognition test consisting of breakpoint and nonbreakpoint slides from the same sequences and from a second set of sequences employing the same actors and settings. Breakpoint items were recognized significantly more accurately than nonbreakpoint items. In a second study, triads of consecutive breakpoints were photographed, as were triads of nonbreakpoints taken from the intervals between the breakpoints. The resulting triads of slides were then presented in correct or incorrect order, and subjects were asked to judge whether or not the presented order was correct. Breakpoint triads were judged with much greater accuracy than nonbreakpoint triads. Comparable differences between breakpoints and nonbreakpoints were also obtained on measures of the accuracy with which subjects could describe the original actions and ratings of the intelligibility of the slide triads.

One implication of these results is that, because the critical action-defining information is not continuously present, continuous processing is not required for action perception. Newtson, Lightner and Pennebaker (Note 1) illustrated this by asking adult subjects to close a shutter eliminating their view of the behavior stream "whenever you don't need to watch to keep track of what's going on." Subjects eliminated 48 per cent of a predictable sequence, and 26 per cent of an unpredictable sequence without affecting their memory for the events.

These findings imply that competent perceivers of action must be able to discriminate breakpoints in the behavior stream. It would follow, therefore,

that recognition memory for breakpoints should be superior to that for nonbreakpoints at all ages where competence in action perception exists.

Perceiver constraints in action perception. While studies of the behavior stream as a stimulus have focussed on the differential objective and informational properties of breakpoints, other studies have demonstrated that perceiver variables may strongly influence breakpoint selection. That is, while certain properties of stimulus points seem necessary for their selection as action-defining breakpoints (cf. Newtson, Rindner, Miller & LaCross, 1978), the behavior stream is frequently complex enough to provide the observer with a number of alternatives. Variables such as prior expectations about the motives and characteristics of event participants (Engquist, Newtson and LaCross, Note 2; Massad, Hubbard and Newtson, 1979), task set (Cohen and Ebbesen, 1979), observer skill (Newtson, Rindner & Campbell, Note 3), and instructions as to how closely to analyze behavior (Newtson, 1973; Newtson and Rindner, 1979) have been shown to alter breakpoint selections in ways that correspond to differences in action interpretation. These studies clearly indicate that cognitive factors play an important role in action perception. Only one study, however, has investigated breakpoint discrimination over age.

Engquist (in press) composed two sequences of simple events with identical patterns of breakpoints (this was verified by an adult sample) and identical amounts of movement. These films were shown to adults and children 6, 8 and 12 years of age under one of three conditions: 1) one film alone; 2) visually overlapped, but such that the breakpoints in each sequence never occurred simultaneously; and 3) visually overlapped, but such that the breakpoints in each sequence always co-occurred. Neisser and Becklin (1975) had used visually overlapped sequences with adults, in a kind of visual analogue of the selective listening paradigm. They reported that subjects had no difficulty in following

one episode rather than the other, and that odd or unusual events in the to-be-ignored episode were simply not noticed. Neisser and Becklin (1975) concluded that their results provided direct evidence for cognitive control of event perception, since the kind of peripheral filter mechanisms postulated by selective attention theories to explain such effects in auditory presentations could not have been learned for visually overlapped material.

Engquist (in press) asked her subjects to track the occurrence of specific, repeated actions by pressing a button whenever they occurred. Following viewing, subjects responded to a multiple-choice memory measure. In the single-film conditions, memory for the action improved from six to eight, and from eight to twelve, reaching adult levels by twelve years of age. In the visually superimposed conditions, subjects were instructed to track occurrences in one of the two films. Memory was then assessed for both the to-be-followed and to-be-ignored films; greater memory for the to-be-followed film than for the to-be-ignored film may thus be taken as an index of selectivity.

When the breakpoints in the superimposed films did not occur simultaneously, a selective memory advantage for the to-be-followed sequence emerged by age eight, and memory was nearly as good as that of 12-year-olds and adults. When the breakpoints in the superimposed films occurred simultaneously, however, selective memory did not emerge until twelve years of age. Twelve-year-olds performed as well as adults, while eight-year-olds did as poorly as six-year-olds under these viewing conditions.

Engquist's (in press) data raise important questions about children's ability to organize ongoing behavior. Her data suggest that breakpoints play an important role in action perception at least by the age eight, since a manipulation that made breakpoints more difficult to discriminate (the simultaneous superimposition manipulation) clearly affected eight-year-old's selective memory for the event.

It is not clear, however, which aspect of the cognitive-perceptual interaction was affected by this manipulation. That is, Engquist's (in press) results could have been due to both difficulty in discriminating breakpoints as well as in interpreting breakpoint information (which could further interfere with subsequent breakpoint selection). Engquist's sequences were quite simple, one of them showing a person placing potted plants from a tray onto a table, and the other showing a person pinning letters and numbers on a bulletin board. She instructed her subjects to press a button whenever the person "put a plant on the table," or "pinned a number to the board." Engquist (in press) scored the resulting records for accuracy and found that six-year-olds failed to record 42 percent of the specified events in the single film conditions; this dropped to 23 percent for eight-year-olds, while both twelve-year-olds and adults performed nearly without error. When films were overlapped the only significant increase in errors within age level that was observed on this task was for six-year-olds, and that only when breakpoints in the two films coincided in time. Thus age level differences may have reflected problems with task comprehension or in coordination of the response with perception; the only direct evidence for perceptual effects of the manipulations that was obtained was for six-year-olds.

The Present Research

Two of the studies of the informational value of breakpoints reported by Newtson and Engquist (1976) were replicated in modified format over age. Adult subjects and children five, seven and nine years of age were tested for recognition memory for slides of breakpoints and nonbreakpoints, and were also asked to judge the ordering of triads of breakpoints and nonbreakpoints presented in correct and incorrect order. The recognition task simply assesses the degree to which subjects are sensitive to high information points in the behavior stream, depending only minimally upon interpretive processes. The slide triad task assesses the ability to interpret an important dimension of stimulus information, temporal

order, free of the necessity of discriminating that information from the ongoing behavior stream. The two studies were conducted together. Subjects first viewed the memory films then judged the triads of slides, and then were tested for recognition of items from the films. They are presented separately as matter of convenience in exposition.

Experiment One

In this experiment, subjects viewed two 30-second films showing a male performing a simple series of actions. Following an intervening task lasting about ten minutes (Experiment Two, see below), subjects were tested for recognition memory for breakpoints and nonbreakpoints taken from the films they had seen and from two other films. Foil items were drawn from two additional films employing the same actor and physical objects, but differing in their action contents. This was counterbalanced in the design so that each item was an "old" item for half of the subjects, and a "new" item for the other half.

To the extent that our reasoning from previous studies of the behavior stream is correct, recognition memory for breakpoint items should be superior to recognition memory for nonbreakpoint items at all age levels. Evidence that breakpoints are not better recognized than nonbreakpoints until ages seven or nine would imply either that young children perceive behavior in a fundamentally different way than adults, or that our reasoning that behavioral information typically occurs intermittently in the behavior stream is incorrect.

Method

Subjects. Subjects were 17 kindergarten children (12 males, 5 females, mean age 5.3 years), 16 second-graders (6 males, 10 females, mean age 7.5 years), 16 fourth-graders (7 males, 9 females, mean age 9.5 years), and 16 college students, (8 males, 8 females).

Stimuli. Four 30-second simple action sequences were filmed on Super 8 movie film. Two actors performed in each of two films using the same settings and objects.

One set of sequences showed a male actor either a) picking up pencils one by one and sharpening them with a hand pencil sharpener or b)throwing pencils one by one into a waste basket. The second set of sequences showed another male actor either a) hammering nails into a piece of wood or b) pulling nails out of a piece of wood with a hammer.

Six items (3 breakpoints and 3 nonbreakpoints) were identified in each film from the segmentations of a pretest group of sixteen adult subjects who viewed the sequences under instructions to press a button whenever, in their judgment, an action occurred. Responses were recorded with an event recorder, and these records were combined over subjects for each one second interval of the film. Breakpoints were identified as those intervals where the number of responses totaled one standard deviation above the mean number responses per interval. Nonbreakpoints were identified as intervals where number of responses totaled one standard deviation below the mean number of responses per interval (cf. Newtson and Engquist, 1976). The frame from the center of each interval so identified was photographed. Both films and photographs were in color. For all sequences, breakpoints and nonbreakpoints were selected alternately in time.

Procedure. Subjects were tested individually. At the beginning of each session, subjects were told that they were to see two short movies, and that they were to "try not to miss anything." Half of the subjects then viewed the pencil throwing and nail pulling sequences, while the other half viewed the pencil sharpening and nail driving sequences.

Subjects then performed the tasks in Experiment Two (see below), which consisted of viewing a series of slide triads, and judging their order. This task lasted 5-7 minutes. Upon completion of these tasks, the experimenter reminded subjects of the films they had seen initially, and said he had some pictures that were taken from those movies and some pictures that, "just look like" they came from those movies. He then asked subjects to "guess which

pictures came from the movies and which did not." Items were then presented one by one in a fixed, randomly determined order in all conditions, and the experimenter recorded subjects' judgments.

Design and Analysis. The data for the recognition task consisted of 24 yes-no responses which were analyzed by calculating A' values for each of the two sequences each subjects observed (Snodgrass, 1975; Snodgrass, Volvowitz, & Walfish, 1972). This procedure is a nonparametric alternative to standard signal detection analysis, where the index of sensitivity is calculated from the signal and noise distributions. The formula for this index, where H is the probability of a correct response and FA is the probability of a "false alarm" or incorrect response is: $A'=(H - FA)(1 + H - FA)/4H(1 - FA)$. These values were calculated separately for breakpoints and nonbreakpoints. A' values were entered into a 4 X 2 X 2 X 2 mixed analysis of variance, using MANOVA for repeated measures. The between-groups factors were Age (kindergarten, second grade, fourth grade vs. adult), Sex (male vs. female), and Presentation Group (1 vs. 2). The repeated measure was Point Type (breakpoint vs. nonbreakpoint).

Results

The analysis of variance yielded significant main effects for Point Type ($F(1,49) = 33.84$, $p<.001$), Age ($F(3,49) = 9.24$, $p<.001$), Presentation Group ($F(1,49) = 5.40$, $p<.03$), and a Presentation Group by Point Type interaction ($F(1,49) = 11.56$, $p<.001$). No other effects or interactions were significant.

Overall, mean accuracy was greater (.862) for breakpoints than for nonbreakpoints (.739). Mean accuracy was greater for the nail hammering and pencil sharpening sequences ($\bar{X} = .836$) than for the nail pulling and pencil throwing sequences ($\bar{X} = .765$), as indicated by the Presentation Group main effect. The Presentation Group by Point Type effect resulted from a larger difference

in recognition accuracy between breakpoints and nonbreakpoints for the nailpulling and pencil throwing sequences ($\bar{X}$'s = 8.58 and .672 for breakpoints and nonbreakpoints, respectively, $t(49) = 6.84$, $p<.001$) than for the nail driving and pencil sharpening sequences ($\bar{X}$'s = .867 and .805 for breakpoints and nonbreakpoints, respectively, $t(49) = 2.28$, $p<.05$).

Age trends are graphed in Figure One. A trend analysis conducted within

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Insert Figure 1 about here

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each point type yielded significant linear trends for both breakpoints ($t(61) = 4.32$, $p<.001$) and nonbreakpoints ($t(61) = 4.10$, $p<.001$).

Discussion

As predicted, breakpoints were better recognized than nonbreakpoints at all age levels. This finding suggests that at least by the age of five, children's perception of behavior is not fundamentally different from that of adults. To the extent that breakpoints reflect the fundamental information structure of the behavior stream as a stimulus, this result is not surprising; competent behavior perception would require breakpoint discrimination.

One possible interpretation of the age trend observed is that it reflects more accurate convergence to adult breakpoints with age. Newtson and Engquist (1976) compared the segmentations (i.e. breakpoints selected while viewing the stimulus films) of subjects who were highly accurate and very inaccurate on the recognition test to those of the pretest group whose segmentations had provided the basis for item selection. The segmentations of accurate subjects matched those of the item selection group significantly better than the segmentations of inaccurate subjects. Thus the age trend could reflect an increasing convergence with age to the breakpoints used by adults.

It is also possible, however, that the age trend reflects development of recognition processes in general. Tversky and Teiffer (1976), for example, reported a linear increase in recognition accuracy from ages 5 to 15. Thus the most appropriate interpretation of the age trend cannot be determined from the results of this experiment.

Experiment Two

The results of Experiment One imply that even kindergarteners are able to discriminate breakpoints in the behavior stream. A second study was conducted to examine children's ability to use breakpoint information, independent of their ability to select breakpoints from ongoing behavior. In this study, children viewed triads of breakpoint and nonbreakpoint slides and were asked if the slides were "in the right order to tell a story."

Method

Subjects. Subjects were the same as described for Experiment One.

Stimuli. Items were 24 slides (12 breakpoints and 12 nonbreakpoints). Half of the slides were those used by Newtson & Engquist (1976). Half were prepared for the present study. Slides were drawn from eight sequences showing 1) a man setting out tools; 2) a woman looking for an article in a newspaper; 3) a man answering a phone; 4) a woman cutting out a dress pattern; 5) a woman drinking coffee; 6) a man searching through a desk; 7) a man opening and looking through a book; and 8) a man tipping over a waste basket. Breakpoints and nonbreakpoints were identified from the marking of a pretest group of 16 college-age subjects (cf. Newtson and Engquist, 1976).

Procedure. Subjects were given three practice trials with photographs of different breakpoint triads. They were first given the photographs and asked to arrange them so that they "told the best story." The experimenter then discussed with each subject the action displayed in the pictures. If the subject arranged the

pictures in incorrect order the experimenter put them in the correct order and explained why that was the better arrangement. A fourth practice item was supplied if subjects did poorly on the first three. Practice items consisted of 1) putting on a pair of boots; 2) drinking a glass of soda; 3) breaking a stick; 4) eating a chocolate ice cream bar.

Subjects were next informed that they would see more pictures, but this time as slides. Subjects were told to report after each set of three whether or not the pictures were in the right order to tell a story. The four practice stimuli were again presented, as slides, two in correct order and two in incorrect order. Slides were presented for 5 seconds each, with an interstimulus interval of .75 seconds and 15 seconds between each sequence.

Subjects then viewed eight sets of triads; four sets of breakpoints and four set of nonbreakpoints. Subjects viewed slide sets from any given sequence only once. Selection of sequences for inclusion as breakpoints or nonbreakpoints in the series was done randomly. To balance for presentation order, subjects were assigned to one of two presentation groups. Item sets presented in correct order for one group were presented in incorrect order in the second group, and vice versa.

Scoring, Design and Analysis. Accurate judgments were scored as one, while inaccurate judgments were scored as zero. These data were entered into a 4 X 2 X 2 X 2 mixed effects analysis of variance. The between-groups factors were Age (kindergarten, second grade, fourth grade and adult), Sex, and Presentation Group. The repeated measure was Point Type (breakpoint, nonbreakpoint).

An additional analysis was conducted on the items themselves. Each item was projected onto a translucent piece of paper, and a stick-figure tracing was made of the actor. The fifteen body parts identified by the Eshkol-Wachmann movement notation (Eshkol, 1973; Newtson, Engquist & Bois, 1977) were used to make

these stick figures. These body parts are as follows: head & neck; torso; pelvis; right upper arm; right lower arm, right hand; left upper arm, left lower arm; left hand; right upper leg; right lower leg; right foot; left upper leg; left lower leg; left foot. Two other coding features, frontal orientation and weight distribution, are also included in this notation.

These stick figures were then compared for each pair within each specific triad according to the following procedure: Each of the seventeen features was compared between tracings, and a same-different judgment was made by the coder. For each of the fifteen body features, this required a judgment of whether or not the feature was at a different angle with respect to its pivot joint. Thus, if the arm was raised while maintaining full extension, a difference would be registered for the feature upper arm only, since lower arm and hand maintained the same angle relative to the elbow and the wrist. These judgments could be made efficiently by superimposing the two tracings of the items being compared: despite overall changes in positions, changes in each critical joint angle could be seen by placing the two tracings so that the critical features were lined up (e.g. if comparing the angle of a lower arm between two items to assess a change, the upper arms of the two items could be overlaid so that differences in lower arm angle were readily detectable). Changes in the relative position of limbs then were reflected in either or both differences in limb angle or in their length of the tracing.

Number of features that changed in each item set were summed, yielding a feature change total. Thus there were two "summed features change" indices for each breakpoint and nonbreakpoint item set, one for its correct presentation order and one for its incorrect presentation order. This index could range from zero to 34. The reliability of this coding was assessed by having a second coder judge the 16 combinations of items over four sequences, and correlating

the resulting values from the two sets of coding. This value was .89 ($t(14)$ = 7.71, $p<.001$).

These values were then averaged across presentation order and correlated with mean accuracy of judgment within each age group and point type.

Results

The means for judgmental accuracy are presented in Table one. Analysis of variance indicated a significant main effect for Point Type ($F(1,49)$ = 6.72, $p<.02$). Overall, mean accuracy was .64 for breakpoint triads, and .53 for nonbreakpoint triads. The Point Type be Presentation Group interaction was also significant, however ($F(1,49)$ = 8.78, $p<.005$); subsequent comparisons indicated that this effect consisted of a significant Point Type effect within one presentation group for breakpoints and nonbreakpoints (means were .69 and .45 respectively, $t(64)$ = 2.83, $p<.005$) but not for the second presentation group (means were .58 and .60, respectively, $t(64)$ = .28).

The main effect for Age was also significant ($F(3,49)$ = 3.206, $p<.05$). Planned comparisons with two-tailed t-tests showed marginally significant linear trends for both breakpoint ($t(61)$ = 1.89, $p<.10$) and nonbreakpoint ($t(61)$ = 1.68, $p<.10$ items). Quadratic trend comparisons were nonsignificant for breakpoint ($t(61)$ = -.690) and nonbreakpoint items ($t(61)$ = -1.24).

An Age by Presentation Group interaction was also observed ($F(3,49)$ = 5.19, $p<.01$). Subsequent means tests indicated that accuracy in the two presentation groups was generally similar except for adults, where performance in one group was significantly better than in the other. All other effects and interactions in the analysis were nonsignificant.

Analysis of the stimulus items indicated a highly similar degree of change in the item sets. Mean number of feature changes was 19.4 for breakpoint items (17.7 and 21.0 for correct and incorrect presentation order, respectively), and

and 18.8 for nonbreakpoint items (18.0 and 19.5 for correct and incorrect presentation orders, respectively). Correlations between these indices and accuracy within each age level, however, suggested striking differences in the manner in which judgment accuracy was achieved.

For kindergarteners, accuracy of judgment of breakpoint items correlated .98 with the feature change index for breakpoint items ($df = 8$, $p<.01$), and .90 ($df = 8$, $p<.05$) for nonbreakpoint items. By second grade, however, accuracy could no longer be predicted from amount of feature change for breakpoints ($r(8) = -.33$), although the relationship still held for nonbreakpoint items ($r(8) = .94$, $p<.05$). Correlations between amount of item change and judgmental accuracy for breakpoint and nonbreakpoint items, respectively, was .68 and .36 at fourth grade, and .37 and .13 for adults. None of these values were significant.

Discussion

Overall, breakpoint triads were judged more accurately than nonbreakpoint triads, although this was not true for one of the presentation groups. Examination of the means (in Table 1) suggests, as do the correlations between accuracy and degree of change, that kindergarteners used the stimulus information quite differently than the other age groups did. Specifically, kindergarteners tended to identify breakpoints as telling a story regardless of whether they were in proper order. They also tended to reject nonbreakpoints regardless of actual order. The correlations between accuracy and degree of change, it should be noted, were conducted on accuracy scores averaged over orders of presentation, so those correlations represent the relationship between stimulus change and accuracy with the breakpoint-nonbreakpoint response bias cancelled out.

Our results are reminiscent of those reported by Jenkins, Wald and Pittenger (1978). These authors presented evidence that adults remember events

as wholes, rather than in terms of details that supported the apprehension of the event. In one study, subjects viewed a series of slides showing an object orbiting another in a spiral path. Subjects were subsequently tested for recognition memory for slides they had actually seen, slides they had not seen but which were on the path defined by the original stimulus set, and slides they had not seen but which were off the spiral path. Jenkins and his colleagues found that although they could easily reject new items off the specified path, subjects could not discriminate new items that were on the path from those (old) items that had originally defined the path. Thus they concluded that their subjects remembered the abstraction, the "event" - i.e. the path - rather than the specific details that supported its apprehension - i.e. the original slide set.

Something quite similar may happen in action perception, but with one important difference. Jenkins et. al.'s (1978) event was defined continuously, as physical-motion events typically are, while actions appear to be defined discontinuously. Thus, persons viewing a behavioral event may remember an abstraction - the actions that occurred - and when tested for recognition memory for slides they may try to fit each slide to the remembered action set. Breakpoints appear to have a relatively unambiguous relationship to remembered actions, however, in that they either fit remembered actions or not. Thus, in behavior perception, "new" breakpoints are typically rejected as readily as "old" breakpoints are accepted. By contrast, nonbreakpoints are more ambiguous; they seem relatively indefinite with respect to the set of abstract transformations that are the remembered set of actions.

The fact that breakpoints were more readily recognized than nonbreakpoints even by five-year-olds suggests that by this age children are already sensitive to the action-relevant properties of breakpoints. The finding of a response bias in the second experiment towards seeing breakpoints as more like to "tell a story" is also consistent with this conclusion. Young children seem aware that

these items are likely to enter into action-defining transformations. Their apparent reliance on physical differences to order breakpoint triads accurately, however, suggests that their knowledge of such action-defining transformations is not yet well-developed.

The present data are generally consistent with Brown's (1976) findings on children's ability to remember and reconstruct the ordering of events, but they do raise some additional issues. First, Brown (1976) has been concerned with ruling out "inherent" order information in order to show, for example, that pictures presented with logical connections are better remembered than those presented arbitrarily. Our concern in Experiment Two was to investigate the conditions under which "inherent" order information is present for subjects of different ages. Differences between kindergartners and older children in correlations between feature change and accuracy of order judgments imply that what constitutes inherent order information may change with age. For example, it might be that older children and adults are able to consider the triad of items as a whole, rather than evaluating each pair independently. Research with adults (Newtson, Toris & Engquist, Note 4) has shown that performance on breakpoint triads in superior to what could be predicted from performance on their component pairs (e.g. accuracy of judgment on an A-B-C triad is greater than the expected value generated from judgments of A-B and B-C breakpoint pairs). Thus, adults evaluate not only the relations between item pairs, but also the ordering between the two actions so defined.[1] On the basis of our present results, we would not expect kindergartners to show this performance again. This prediction would also be consistent with other findings suggesting

that young children have difficulty dealing with relations among individual actions (Brown, 1976; Collins, Wellman, Keniston & Westby, 1978; Livesly & Bromley, 1973).

A second set of issues raised by the present research concerns the use of a successive as opposed to a simultaneous presentation format in Experiment Two. Brown (1976) indicates that preschool children can reconstruct a sequence of pictures from memory as well as first-graders if the pictures are presented simultaneously "as a unit" (p. 44), but perform less well when pictures are presented successively (one at a time). Thus, one might argue that the present findings would not be obtained if triads had been presented simultaneously. It is important to remember, however, that our items represented (for breakpoints, at least) natural units selected from the behavioral stream, and that successive presentation is, in that sense, more ecologically valid than simultaneous presentation. In addition, we have found that adults will in fact perform more accurately under conditions of successive as opposed to simultaneous presentation when judging breakpoint triads (Newtson, Gowan & Rogier, Note 5).[1]

The present data are also relevant to criticisms of our conception of the behavior perception process. For example, Ebbesen (1980) has argued that the greater feature change typically observed between successive breakpoints as compared to successive nonbreakpoints (Newtson, Engquist & Bois, 1977) may account for the more accurate orderings of breakpoint as compared to nonbreakpoint triads (Newtson & Engquist, 1976). In other words, Ebbesen (1980) has suggested that greater feature change between breakpoints makes inference easier. To the contrary, however, our current results show that although kindergartners may rely on simply feature change information, older children and adults do not.[2] Thus, the present results add further support to the view that behavior perception is not reducible to inference from object and motion perception.

As Livesley and Bromley (1973) noted, the ability to discriminate units of behavior probably develops at an early age. The present data confirm that children are sensitive to the action-defining properties of the behavior stream at least by the age of five. It is intriguing, then, that the cognitive structures which permit selective perception (as in Engquist's (1976) study) and reasonsing about the logical order of immediately presented actions (as suggested by the results of Experiment Two), apparently develop only later. The timing of this development, however, does seem to fit nicely with studies of the development of person perception, which suggest that representations of more abstract, dispositional properties of person emerge at about the same time (Livesley & Bromley, 1973; Rosenberg & Sedlak, 1972). The most significant aspect of the present research, therefore, may lie in its demonstration that paradigms and concepts developed for the study of behavior perception in adults may be used to study this important development.

Reference Notes

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Footnotes

[1]For adults, performance on breakpoint triads is equally accurate under simultaneous (15 sec. total exposure time) or successive (15 sec. exposure time per slide, as in the present study) presentation conditions; speeding the task, however, reduces performance in the simultaneous (3 sec. total exposure time) but not in the successive (1 sec. total exposure time) presentation conditions.

[2]One possible objection might be that our correlations (i.e., between amount of feature change and number of correct judgments) were based on too few degrees of freedom to be considered conclusive. However, these correlations were based on mean accuracy scores and hence represent fairly stable item properties. Moreover, comparable values have been observed in other studies (Newtson, Gowan & Rogier, Note 5).

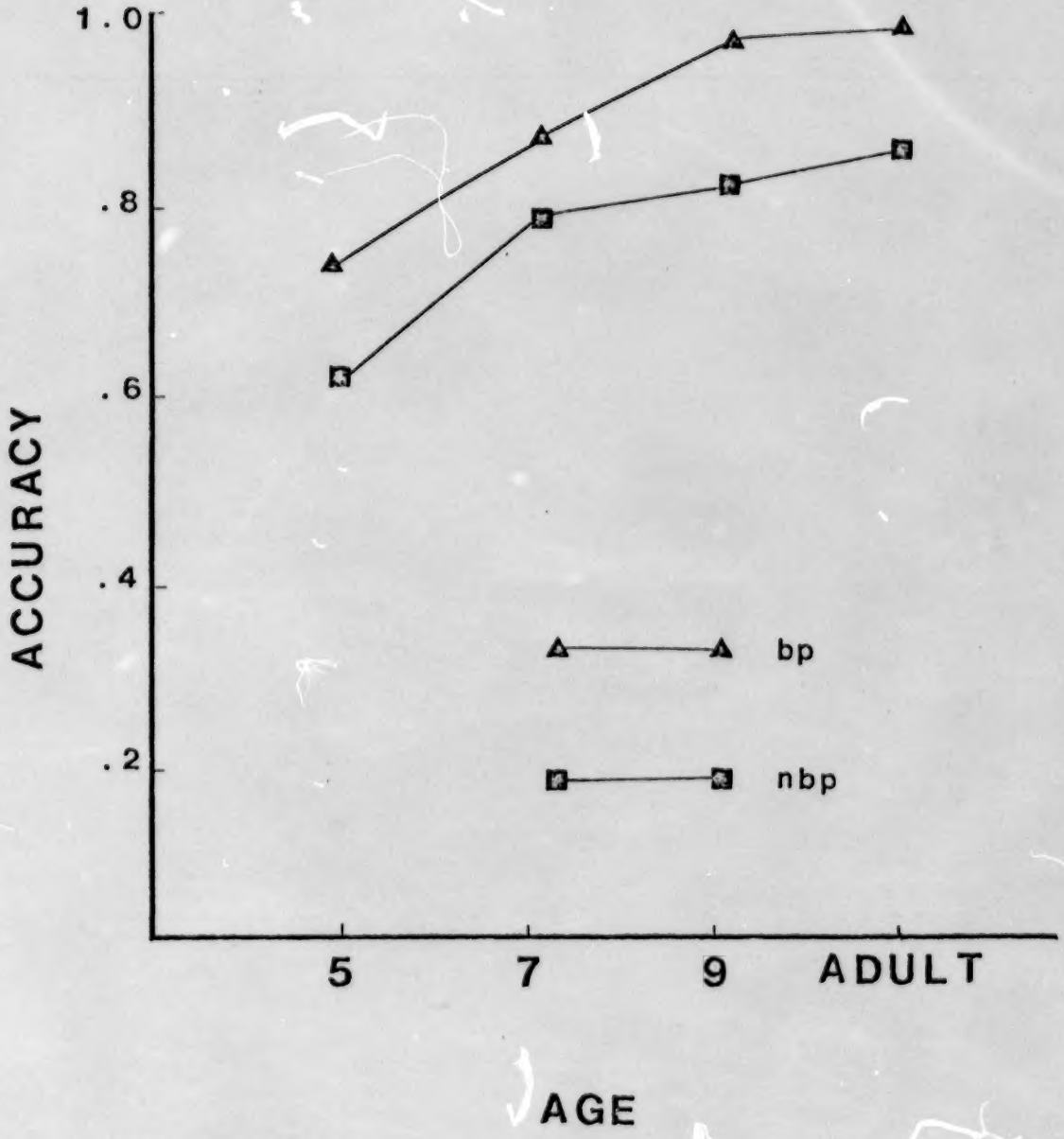
Table One

Accuracy of Order Judgments by Age, Order of Presentation and Item Type.

Age	Item type	Order of Presentation: Correct	Order of Presentation: Incorrect	*t*-value for comparison across Order
5	Breakpoint	.73	.38	4.13*
	Nonbreakpoint	.26	.60	4.00*
8	Breakpoint	.69	.56	1.44
	Nonbreakpoint	.59	.50	1.08
10	Breakpoint	.72	.66	.73
	Nonbreakpoint	.66	.53	1.56
Adult	Breakpoint	.66	.72	.91
	Nonbreakpoint	.63	.50	1.80

* $p < .002$

Note: df for all *t*'s = 64.


1.0
.8
.6
.4
.2
ACCURACY
bp
nbp
5
7
9
ADULT
AGE